PRACTICALS

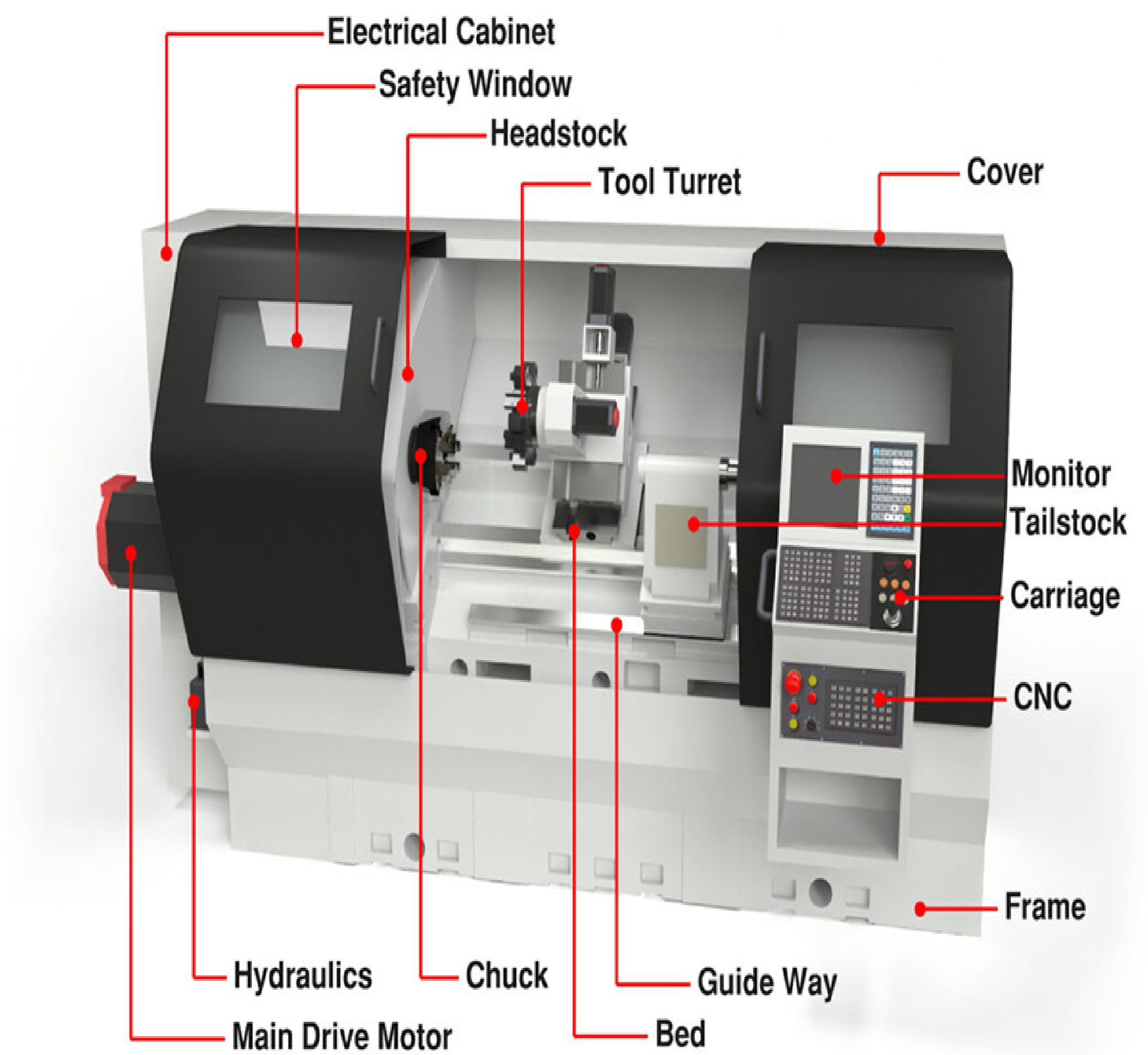
PRACTICAL NO. 1

Aim : Comparative Study of the constructional details of CNC lathe and CNC milling Machine.

Procedure : The main parts of CNC lathes are as the following :

1. Bed : Bed is made of special grade of cast iron. For example ; FG-260 IS : 210 for high rigidity, wear resistance and non-distortion. The bed is *generally*, provided with maximum and wide chutes for immediate disposal of chips and coolant etc. Bed casting is stress-relieved before using. The guideways are flame hardened and precision ground upto fine limits by slideway grinding machine.

Bed is a slant bed design *i.e.*, it is inclined at 45° to 60° to the ground but in special cases, this slant angle can be increased to 75°. These days, vertical bed (*slant angle 90° to the ground*) is also provided. This slant bed design has many advantages over the horizontal bed like free flow of chips and coolant and easy loading and unloading of components due to the absence of any projection in front of the machine. (Fig. 1.2).



CNC LATHE

2. Headstock : The headstock body is designed for almost rigidity and is selected from suitable grade mechanite of cast iron. It contains specially designed spindle mounting with high accuracy for vibration free performance. All gears are fabricated nickel-chrome alloy steel, case hardened and profile ground. The sliding cluster gears slide on the hardened and ground spline shafts. Lubrication is provided by a separate pump drawing oil from the sump and delivers to all the gears and bearings. It is provided by a motor driven pump which is coupled with the headstock unit at the backside. For failsafe, a mercury switch with swinging arm is provided, used for stopping the operation of machine in case of lubrication failure.

3. Spindle : The spindle is made of carbon steel forging and ground upto the fine limits of tolerances. It undergoes multiple operations and heat treatment. CNC lathes are available with a variety of motor size ranging from 5 to 60 HP and spindle speeds from 20 to 4800 r.p.m. Super speed CNC lathes are provided with powerful and rigid high speed spindle. High output 26 kW spindle motor is provided in such machines and spindle has a fast speed response from 0 to 4500 r.p.m. in just 5 seconds.

4. Saddle : A saddle perfectly matched and aligned is provided in CNC lathe machines for vibration free operation. It is generally made of special grade of cast iron and is provided on the bed guideways. The saddle is lined with non-metallic lining. For example, turcite or equivalent. The saddle guideways are hand scrapped to match the bed profile. For the cross-slide, hardened and ground guideways are provided on the saddle.

5. Cross-slide : A rigid cross-slide is provided on the saddle. The cross-slide is also lined with turcite lining and is sufficiently long to give it the desired stability. The provision of centralised lubrication system for saddle and cross-slide prevents the stick-slip motion and gives better positioning accuracy.

6. Hydraulic counter balancing system : The cross slide is provided with hydraulic counter balancing system so that the ball screw for X-axis is not strained. It is also provided for smooth and accurate movement.

7. Feed rotary drive : Feed drive to Z and X-axes is provided by servo motors precision ball screws, with double nuts and rotary resolvers. The ball screws are mounted on precision anti-friction bearings. The rotary resolvers provide the system with unidirectional slide positioning repeatability of ± 0·005 mm. The rapid traversing of X and Z-axes is possible upto 20 m/min. and 24 m/min. respectively with a cutting feed rate of 0·001 – 500 mm/rev.

8. Feedback system : Feedback system to the servo drive is provided by linear/rotary encoders for axes and spindle.

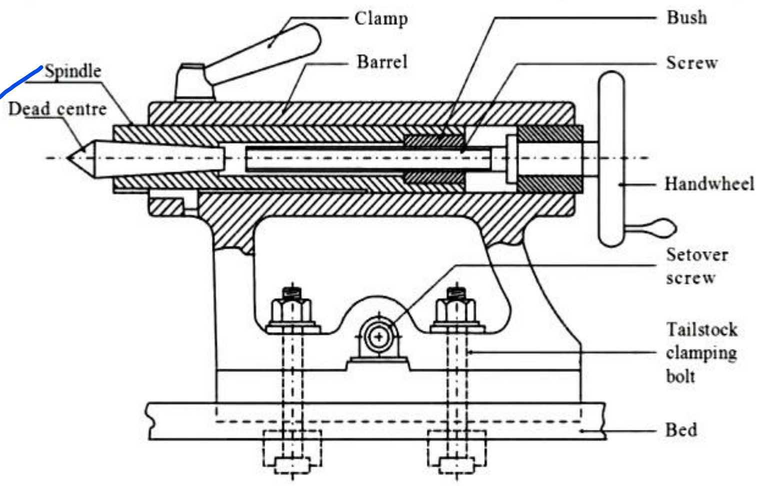
9. Hydraulic power pack : A hydraulic power pack provides the desired function for tailstock actuation, tailstock clamping, gear shifting, chuck actuation and counter balancing.

10. Tailstock : Different types of tailstocks can be provided in different CNC lathes. For example, manual tailstock, manual adjust and hydraulic quill located tailstock or tape controlled tailstock etc. The tailstock is sturdy in construction and perfectly matched and aligned with guideways. It slides over the entire length on inverted 'V' and flat guideways of the bed. Four clamping bolts are provided with the bed for positive locking.

A long, large dia. quill duly hardened and ground is very much suited to withstand heavy job load. The to and fro movement of the quill is provided with graduated dial. For easy sliding of the unit, a crank lever is provided with rack and pinion.

Tape controlled tailstock is moved by tape command using switches as control panel.

Tape controlled swing up tailstock adds flexibility and versatility to the CNC lathes. For external machining, it swings up to support the workpiece and for internal machining, it swings to allow the machine to perform its operation.

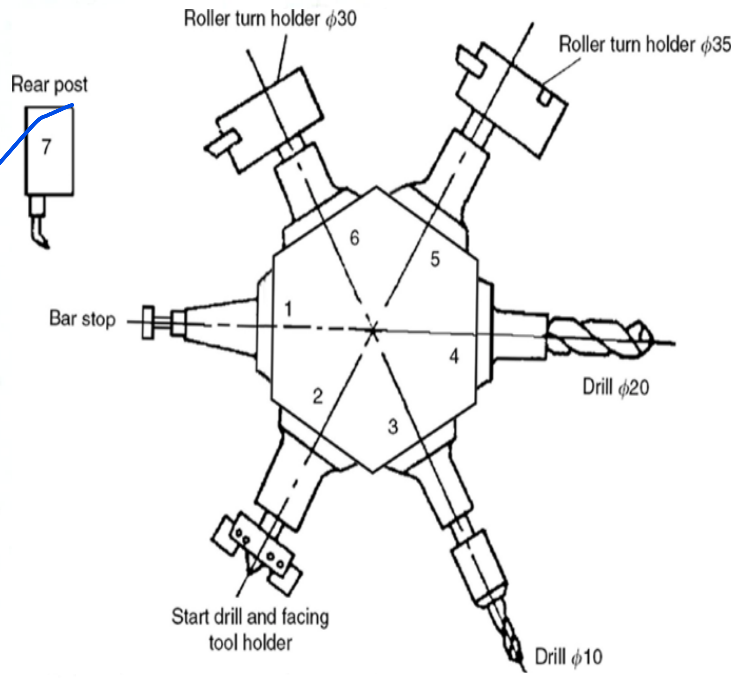


Tailstock

Fig. 1.5. Tailstock of a heavy duty CNC lathe.

11. Turret : The type, style and number of turrets on a CNC lathe machine varies according to size and type of lathe machine. The commonly used turrets are disc turret, drum turret and square turret. In vertical CNC lathe, a straight of flat turret is used. Disk, drum and square turrets operate in horizontal axis but straight turret operates in vertical axis. The disk type of turrets are generally with 8 positions to hold 8 tools or with 12 positions to hold 12 external tools as per the option selected are most commonly used.

The CNC lathes are provided with hydraulic cam type turrets. These turrets can also be electrically controlled.



Tool Turret

12. Steady rest : CNC lathes have hydraulically actuated steady rest as an optional feature. By this pass through steady rest, the deflection for long and slender shaft is minimized. These can be utilized for external and internal machinings.

13. CNC system : CNC lathes are equipped with a particular type of CNC system depending upon the individual manufacturer's specification. A number of CNC systems such as Fanuc 0-TD, Fagor, Siemens, GE 2000 etc. are available these days. These CNC systems can undertake all normal functions for a CNC lathe like turning, contouring, thread cutting, drilling, boring etc. Each CNC lathe has a particular CNC system and this system enables the operator to make programs, see the graphic display, perform comprehensive diagnostics, run a program in single mode, automode and as a dry run. Various backlash and pitch error compensations are also provided.

Modern CNC lathes are equipped with "fuzzy control" system which makes the operation and maintenance of CNC lathes very economical and easy.

CNC Milling Machine

Procedure : Main parts of CNC milling machine are as the following :

1. Base : It is a heavy grey iron casting provided at the bottom of the machine. It is accurately machined on both the top and bottom surfaces and acts as load bearing member for all other parts of the machine. *Column* of the machine is secured to it and it carries the *screw jack* with supports and moves the knee.

2. Column : The column is the main supporting frame mounted vertically on the base. It is box shaped, heavily ribbed inside and houses all the driving mechanisms for the spindle and table feed. The front vertical face of the column is accurately machined and is provided with dovetail guideways to support the knee. The top of the column is finished to hold an overarm extends outward at the front of the machine.

3. Slide and slideways : The conventional machine tools are provided with tables, slides, carriages etc. which carry the workpiece or cutting tool etc. These are sliding parts in nature and mounted on the ways that are fixed on the other parts of the machine known as sliding ways. In CNC machine tool slideways, the frictional resistance of slide is more important. Most of the

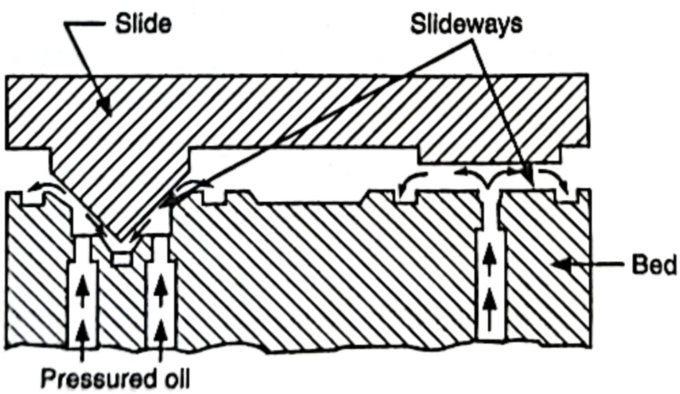


Fig. 2.1. Hydrostatically lubricated slideways.

CNC machines are equipped with hydrostatic oil lubricated slideways, in which a constant film of some oil prevents metallic contact between the sliding members, thereby reducing wear to a minimum. Oil is pumped into small cavities in contact with the slideways of the machine. The pressure of the fluid gradually reduces to atmospheric as it seeps out of the pockets, through the gap between the contacting faces of the carriage and slideways.

An almost frictionless condition exists for the movement of the carriage

The friction is minimised by forcing oil under pressure between the mating surfaces and the pressure is automatically varied, according to the load on the surface resulting from the weight of moving member and cutting conditions.

4. Knee : Knee is rigid casting capable of sliding up and down along the vertical ways on the front face of the column. Therefore, the adjustment of the height. The adjustment is provided by operating the *elevating jack*, provided below the knee, by means of hand wheel or application of power feed. Machined horizontal ways are provided on the top surface of the knee for the cross traverse of the *saddle*, and therefore the *table*. For efficient operation of the machine, rigidity of the knee and accuracy of its ways is instrumental. Two bolts are usually provided on the front of the knee for securing the braces to it to ensure greater rigidity under heavy loads.

5. Table : Table acts as a support for the work. The latter is mounted on it either directly or held in the *dividing head*. It is made of cast iron, with its top surface accurately machined. Its top has longitudinal *T-slots* which accommodate the *clamping bolts* for fixing the work. Also, the cutting fluid, drains back to the *reservoir* through these slots. Longitudinal feed is provided to it by means of a *hand wheel* fitted on one side of the *feed screw*. Sometimes the hand wheels are provided on both sides or alternatively a *detachable handle* is provided. Cross feed is provided by moving the *saddle* and vertical feed by raising or lowering the *knee*. The *adjustable stops* should be used to trip out the same at the correct moment in case the power feed is provided.

In addition to the above feeds, most of the modern milling machines carry mechanisms to provide *rapid traverse* in all the three directions. This saves time. In *universal* milling machines, the table has a *graduated circular* base resting on the saddle. Such a table can be swivelled in a horizontal plane around the centre of its base and the graduations on the letter help in adjusting the required swivel.

6. Overhanging arm : The overhanging arm mounted on the top of the column extends beyond the column face and provides a bearing support for the other end of the arbor. The arm is adjustable so that one or more bearing support may be provided nearest to the cutter.

7. Front brace : The front brace is an extra support fitted between the knee and the overarm to enhance rigidity to the arbor and the knee. The front brace is slotted to allow for the adjustment of the height of the knee relative to the overarm.

8. Spindle : It is the expensive and live part of the machine tool which gets the power from its drive unit and deliver to the work in case of lathe or to the tool in case of drilling or milling machine. There are three main functions of the spindle as :

(*i*) Centering the job or the tool
(*ii*) Holding the job or the tool
(*iii*) Rotate the job or the tool.

Therefore, on the basis of above functions, it should be stiff and short in length to get increased stability and minimisation of torsional strain. It should also be very close to the front bearings to maintain stability and smooth operation.

The centering of the spindle is made by providing either internal or external tapers or cylinders. In case of milling machine, the spindle and internal taper, locates the milling heads or cutter heads.

A straight fastening rod passing through the full length of the spindle is as shown in Fig. 2.2.

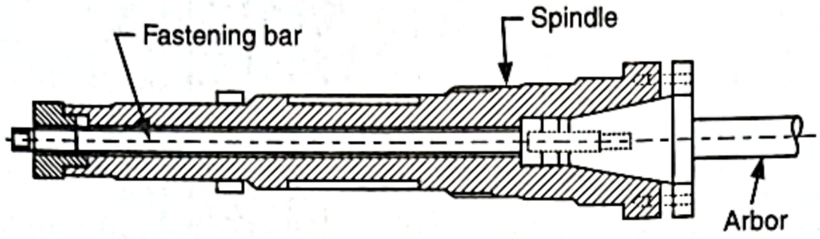


Fig. 2.2. Milling machine spindle.

The tenons (*projections*) are secured to the spindle nose with the help of screws which transmit the torque from the spindle to the arbor or milling head.

9. Arbor : An arbor is an extension of the machine spindle on which milling cutters are securely mounted and rotated. The arbors are made with taper shanks for proper alignment with the machine spindles which have taper holes at their nose. The taper shank of the arbor conforms to the Morse taper of self release taper of value 7 : 24. The arbor may be supported at the farthest end from the overcharging arm and of cantilever type which is called stub arbor. According to the Indian standard specification, arbors with Morse taper shanks are available from 13 to 60 mm in diameter and arbors with self release are available from 13 to 100 mm in diameter. The arbor shanks are gripped against the spindle taper by a *draw bolt* extending throughout the length of the hollow spindle. The threaded end of the draw bolt is fastened to the tapped hole of the arbor shank and then the locknut is tightened against the spindle. The arbor shanks inside gripping it firmly against the taper hole of the spindle. The spindle also has two keys for imparting positive drive to the arbor in addition to the friction developed in the taper surfaces. The ejection of the arbor is affected by unscrewing the locknut and then rapping the draw bolt lightly. The cutter is placed at the required position of the arbor by spacing collars or spacers of various lengths having equal diameter. The entire assembly of the

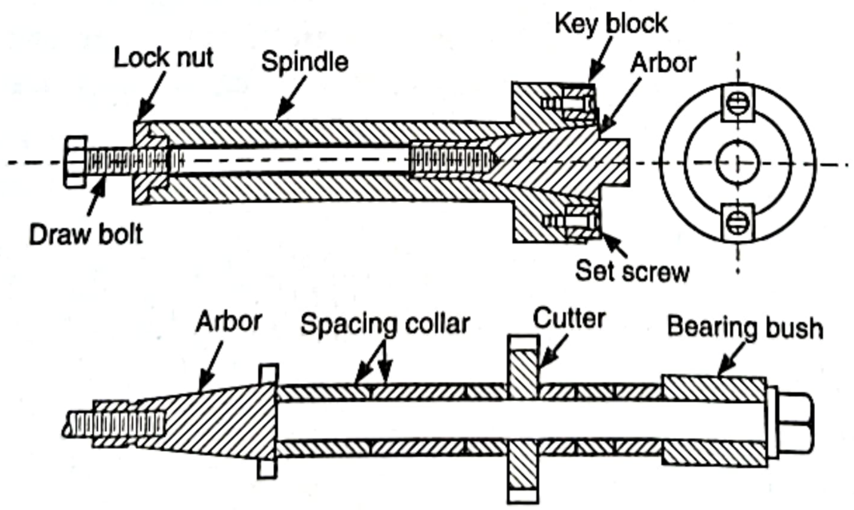
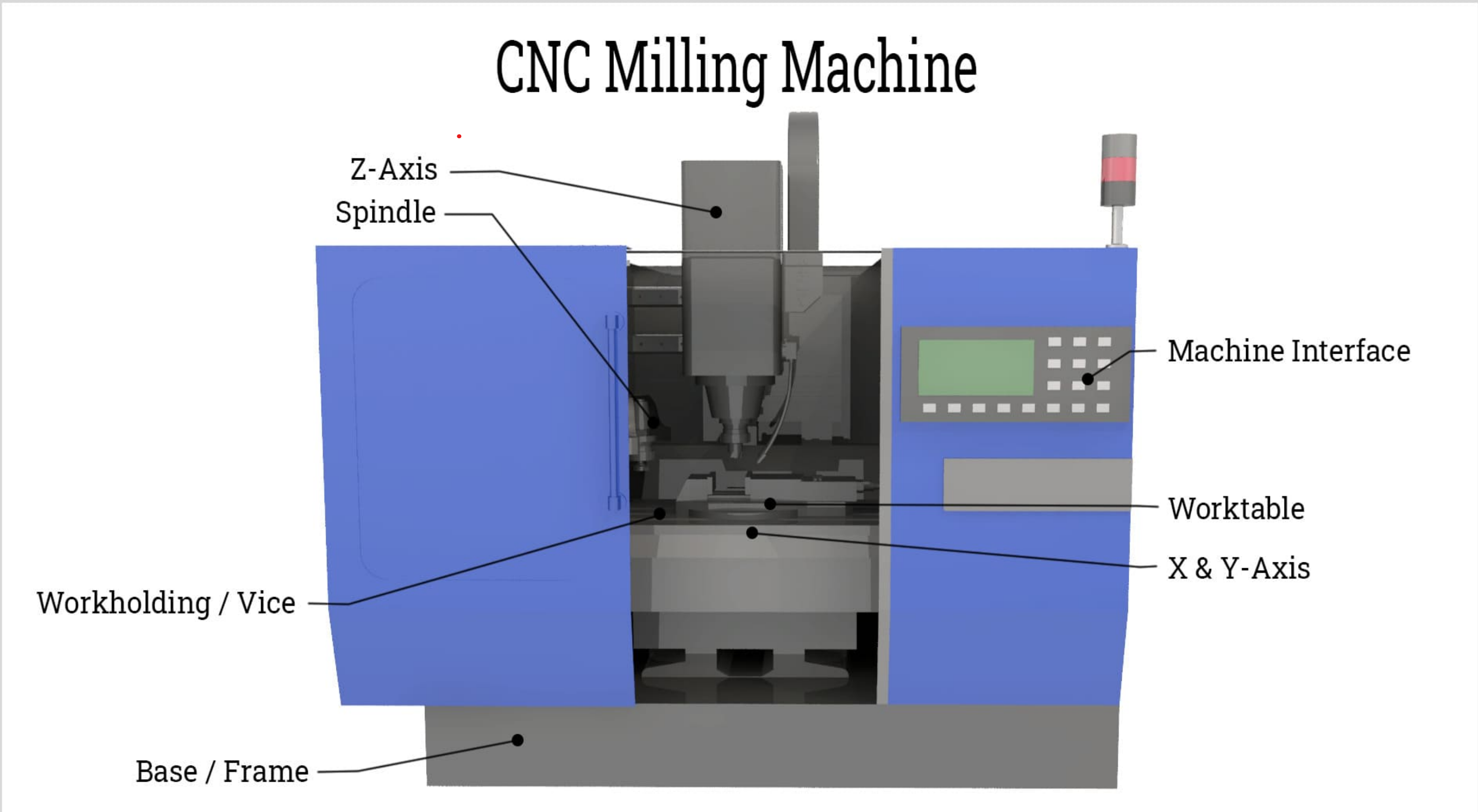


Fig. 2.3. Arbor assembly.

milling cutter and the spacers are fastened to the arbor by a long key. The end spacer on the arbor is slightly more in diameter and acts as a bearing bush for bearing support extending from the overarm. The whole set-up is locked from the end by the arbor nut.

10. CNC system : CNC milling machines are equipped with a particular type of CNC system which depends upon the manufacturer's specifications. These CNC systems can perform all the functions of milling machine. This system helps the operator to make part programs, run a program as a dry run and perform comprehensive diagnostics.



Practical No. 2

Aim:- Comparative study of internation standard codes G-Codes and M-codes for major operations

Preparatory function (G-Codes).

Code	**Description**	**Milling (M)**	**Turning (T)**	**Corollary info**
G00	Rapid positioning	M	T	
G01	Linear interpolation	M	T	
GO2	Circular interpolation, clockwise	M	T	.
G03	Circular interpolation, counter clockwise	M	T	
G04	Dwell	M	T	Takes an address for dwell period (may be X, U, or P). The dwell period is specified in the controller's parameter, typically milliseconds.
G17	XY plane selection	M		
G18	ZX plane selection	M	T	
G19	YZ plane selection	M		
G20	Programming in inches	M	T	
G21	Programming in millimetres (mm)	M	T	
G28	Return to home position (machine zero, aka machine reference point)	M	T	Takes X Y Z addresses which define the intermediate point that the tool tip will pass through on its way home to machine zero. They are in terms of part zero (aka program zero), NOT machine zero.
G40	Tool radius compensation off	M	T	Cancels G41 or G42.
G41	Tool radius compensation left	M	T	**Milling:** Given right hand-helix cutter and M03 spindle direction, G41 corresponds to climb milling (down milling). Takes an address (D or H) that calls an offset register value for radius.

G42	Tool radius compensation right	M	T	Similar corollary info as for G41. Given right hand-helix cutter and M03 spindle direction, G42 corresponds to conventional milling (up milling).See also the comments for G41.
G43	Tool height offset compensation negative	M		Takes an address, usually H, to call the tool length offset register value. The value is *negative* because it will be *added* to the gauge line position. G43 is the commonly used version (vs. G44).
G44	Tool height offset compensation positive	M		Takes an address, usually H, to call the tool length offset register value. The value is *positive* because it will be *subtracted* from the gauge line position. G44 is the seldom-used version (vs. G43).
G49	Tool length offset compensation cancel	M		Cancels G43 or G44.
G50	Scaling function cancel	M		
G52	Local coordinate system (LCS)	M		Temporarily shifts program zero to a new location. This simplifies programming in some cases.
G53	Machine coordinate system	M	T	
G54 to G59	Work coordinate systems (WCSs)	M	T	
G54.1 P1 to P48	Extended work coordinate systems	M	T	Up to 48 more WCSs besides the 6 provided as standard by G54 to G59.
G70	Fixed cycle, multiple repetitive cycle, for finishing (including contours)		T	

G71	Fixed cycle, multiple repetitive cycle, for roughing (Z-axis emphasis)		T	
G72	Fixed cycle, multiple repetitive cycle, for roughing (X-axis emphasis)		T	
G73	Fixed cycle, multiple repetitive cycle, for roughing, with pattern repetition		T	
G73	Peck drilling cycle for milling – high-speed (NO full retraction from pecks)	M		Retracts only as far as a clearance increment (system parameter). For when chip breaking is the main concern, but chip clogging of flutes is not.
G74	Peck drilling cycle for turning		T	
G74	Tapping cycle for milling, left-hand thread, M04 spindle direction	M		
G75	Peck grooving cycle for turning		T	
G76	Fine boring cycle for milling	M		
G76	Threading cycle for turning, multiple repetitive cycle		T	
G80	Cancel canned cycle	M	T	**Milling:** Cancels all cycles such as G73, G83, G81, and G86 etc. Z-axis returns either to Z-initial level or R-level, as programmed (G98 or G99, respectively).
G81	Simple drilling cycle	M		No dwell built in

G82	Drilling cycle with dwell	M		Dwells at hole bottom (Z-depth) for the number of milliseconds specified by the P address. Good for when hole bottom finish matters.
G83	Peck drilling cycle (full retraction from pecks)	M		Returns to R-level after each peck. Good for clearing flutes of chips.
G84	Tapping cycle, right-hand thread, M03 spindle direction	M		
G85	Reaming Cycle	M		
G86	Boring Cycle	M		
G90	Absolute programming	M	T	Positioning defined with reference to part zero...
G91	Incremental programming	M	T	Positioning defined with reference to previous position.
G92	Threading cycle, simple cycle		T	
G94	Feedrate per minute	M	T	
G95	Feedrate per revolution	M	T	
G96	Constant surface speed (CSS)		T	Varies spindle speed automatically to achieve a constant surface speed. See speeds and feeds. Takes an S address integer, which is interpreted as sfm in G20 mode or as m/min in G21 mode.
G97	Constant spindle speed	M	T	Takes an S address integer, which is interpreted as rev/min (rpm). The default speed mode per system parameter if no mode is programmed.
G98	Return to initial Z level in canned cycle	M		

G98	Feedrate per minute (group type A)		T	Feedrate per minute is G94 on group type B.
G99	Return to R level in canned cycle	M		
G99	Feedrate per revolution (group type A)		T	Feedrate per revolution is G95 on group type

Miscellaneous functions

M Codes are instructions describing machine functions such as calling the tool, spindle Rotation, coolant on, door close/open etc.

Code	**Description**	**Milling (M)**	**Turning (T)**	**Corollary info**
M00	Compulsory stop	M	T	Non-optional—machine will always stop upon reaching M00 in the program execution.
M01	Optional stop	M	T	Machine will only stop at M01 if operator has pushed the optional stop button.
M02	End of program	M	T	No return to program top; may or may not reset register values.
M03	Spindle on (clockwise rotation)	M	T	The speed of the spindle is determined by the address S.
M04	Spindle on (counter clockwise rotation)	M	T	See comment above at M03.
M05	Spindle stop	M	T	
M06	Automatic tool change (ATC)	M	T	
M07	Coolant on	M	T	
M08	Coolant on (flood)	M	T	
M09	Coolant off	M	T	

M19	Spindle orientation	M	T	Spindle orientation
M21	Mirror, X-axis	M		
M21	Tailstock forward		T	
M22	Mirror, Y-axis	M		
M22	Tailstock backward		T	
M23	Mirror OFF	M		
M30	End of program with return to program top and Rewind	M	T	
M98	Subprogram call	M	T	Takes an address P to specify which subprogram to call, for example, “M98 P8979” calls subprogram O8979.
M99	Subprogram end	M	T	